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DEVICE FOR TREATING PLANAR ELEMENTS WITH A PLASMA JET

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of plasma technology and may be used in electronics and electrical engineering when treating planar elements, for example semiconductor wafers, substrates, printed circuit boards, compact disks and other products.

2. Description of the Related Art

There has been known a device for studying a plasma - surface interaction, comprising a plasma generator, a power source therefor, a system for the plasma generator displacement, a system for displacing samples, a gas distribution system and a control system (see, Theses of the Reports at the 10th All-Union Conference "Low-Temperature Plasma Generators", Part II, Minsk, ITMS Publishers, Academy of Sciences of Byelorussian Soviet Socialist Republic, 1986, p. 135, Kulik P. P., et al.).

This device has a number of disadvantages.

The absence of a quick-operating loading-unloading system results in high time expenditures and, hence, plasma generator energy consumable to no purpose when replacing plates-samples to be treated.

The lack of the possibility to simultaneously treat several plates-samples one after another decreases the output.

The presence in the device of a plurality of control and measuring means which are inhibitory to the performance of a repeated treatment of samples according to a rigidly prescribed cycle, unambiguously defines this device as being a purely research one.

Taken together, all the above-mentioned results in the fact that the device cannot be used under the series production conditions.

The closest prior art has been described in the International application WO 92/21220, H05H 1/40, 1992, disclosing a device for treating wafers with a plasma jet, comprising a plasma jet generator; gas supplying means; a set of holders for wafers to be treated; said holders being structurally made in the form of a turntable having a drive for effecting angular displacement thereof and facing a generator plasma jet directed downwards; each of the holders being made in the form of a horizontal platform to rotate about the axis passing through the center thereof and being perpendicular to a plane of said platform; said plasma jet and wafer holder having the possibility to be displaced with respect to each other in the direction of at least one axis of coordinates and may be in or out of contact with each other.

Main drawbacks associated with this device reside in an underproductivity limited by a large volume of manual operations when loading-unloading the wafers to be treated. In so doing, the wafers treated are inferior in quality due to a

possible damage of their surface when contact-attaching in the holder.

Moreover, the direction of a plasma jet from top to bottom necessitates the measure-taking on the provision of cooling the plasma generator from overheating with upward-coming hot gases formed during operation of the plasma generator.

SUMMARY OF THE INVENTION

According to the present invention, there is provided a device for treating wafers with a plasma jet, comprising a plasma jet generator, gas supplying means, a set of holders for wafers to be treated. The holders have a drive for effecting angular displacement thereof and face a generator plasma jet, each of the holders being made in the form of a horizontal platform to rotate about the axis passing through geometric center thereof and being perpendicular to a plane of said platform. Said plasma jet and wafer holder have the possibility to be displaced with respect to each other in the direction of at least one axis of coordinates and they may be in or out of contact with each other. The device further comprises a manipulator, storage devices for the wafers to be treated, and a closed chamber having a gas exchange system with the wafer holders and a plasma jet generator located inside said chamber such that a plasma jet is directed from bottom upwards in respect of a plane of locating horizontal platforms of said wafer holders. The closed chamber is provided with a window in which a movable shutter is installed. The manipulator is located to contact with said storage devices directly and with said

wafer holder indirectly, through the chamber window. Each of the wafer holders is provided with a limiter at the edges and has its horizontal platform provided with at least three vortex chambers and three tangential channels being perpendicular to a plane of said horizontal platform, wherein each of said vortex chambers is provided with an open portion located on a level end surface of the wafer holder, coupled through a tangential channel to said gas supplying means and located such that vortex flows formed afford holding of the platform near the holder and cooling of its individual areas to equalize, over the wafer surface, an amount of energy used for treating thereof. Said limiters on the wafer holder platforms are fabricated as the rods mounted at an angle $\alpha > 90^{\circ}$ to the plane of said horizontal platform of the wafer holder. In so doing, their length, l, is chosen such that

$$2l \sin (\alpha > 90^{\circ}) > \Delta$$

where Δ denotes a maximum deviation from axisymmetric arrangement of the treated wafers in said storage devices.

The technical result of using the proposed device is attained by the following features in accordance with the present invention.

Provision of the device with a common rotary drive for the holders, said drive being mounted inside the closed chamber and having its actuating mechanism connected to each of the holders, greatly enhances output of the device.

Introduction of a manipulator with storage devices for the wafers to be treated makes it possible to further enhance the

treatment capacity at the expense of reducing a time needed for loading-unloading the wafers.

The use of a wafer holder having at least three vortex chambers and three tangential channels with the axes of said vortex chambers perpendicular to the horizontal platform of the holder, where each of said vortex chambers being coupled to the tangential channel connected to gas supplying means, allows achievement of a stable holding of the wafer to be treated in the vicinity of the holder with a gas gap without touching the wafer and the holder which, in turn, enables to upgrade the treatment quality due to the absence of the touch traces (scratches).

Arrangement of each of the vortex chambers in the holder such that vortex flows formed by said vortex chambers enable the fulfillment, at each site of the wafer surface, of the condition for $Q_0 = Q_1 + Q_2$

where:

Q_0 = const - an amount of energy for heating the wafer in the given site;

Q_1 - an amount of energy received by the given site of the wafer surface with due regard to thermal transparency thereof;

Q_2 - an amount of energy available at the expense of interaction with a material of the wafer surface in the given site,

makes it possible to produce more uniform, and hence, high-quality treatment of the wafer.

This is conditioned by the fact that each vortex chamber, when creating a gas vortex, makes it possible not only to hold

the wafer near the holder but also to cool individual areas of the wafer to be treated. Since in the process for treatment, different sites on the surface of the wafer to be treated are under different thermal conditions, then proceeding from an energy balance, vortex flows enable establishment of the conditions to equalize Q_0 at all sites of the wafer.

The use of limiters on the holders in the form of the rods mounted at an angle $\alpha > 90^\circ$ to the horizontal platform of the holder, with their length, l, being chosen such that

$$2l \sin (\alpha > 90^\circ) > \Delta$$

where Δ denotes a maximum deviation from axisymmetric arrangement of the wafers in said storage devices, offers a required accuracy when loading-unloading the wafers, without using additional centering means.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will be apparent from the following description when taken in connection with the accompanying drawings, in which:

FIG. 1 is a view showing a device for treating wafers with a plasma jet;

FIG. 2 is a view A of FIG. 1;

FIG. 3 is a functional diagram of an actuating mechanism of a common rotary drive for holders;

FIG. 4 is a view showing a wafer holder;

FIG. 5 is a sectional view A-A of FIG. 4.

BEST MODE TO CARRY OUT THE INVENTION

Referring to FIGS. 1, 2, there is illustrated a device for treating wafers with a plasma jet, comprising a closed chamber 1; a gas exchange system 2; a power supply unit 3; gas supplying means 4, a control system 5. The closed chamber 1 is provided with a window 6 in which a movable shutter 7 with a drive 8 is installed. Inside the closed chamber 1, on a base 9, there are located a generator 10 of a plasma jet 11, an angular displacement drive 12 with its upright shaft 13 coupled to holders 14. The generator 10 of the plasma jet 11 facing the holders 14 is mounted on the base 9 on a support 15 adjustable for height such that the axis of the plasma jet 11 and respective axes of each of the holders 14 are equidistant from the axis of the upright shaft 13 of the angular displacement drive 12. Referring to FIG. 4, the holders 14 are made in the form of horizontal platforms 16 with limiters 17. Said limiters 17 are fabricated as the rods, for example cylindrical rods. With reference to FIG. 3, it is seen that the horizontal platforms 16 are set in rotation about their axes by a drive 18, for example by means of an actuating mechanism 19 through a step-by-step interaction of its gears 20, 21, 22 and pulleys 23, 24. It is illustrated in FIGS. 4 and 5 that the horizontal platforms 16 are provided with vortex chambers 25 each having an open portion located on a level end surface of the holder 14 and coupling to a tangential channel 26 connected to said gas supplying means 4. It is shown in FIG. 1 that outside the closed chamber 1, on the base 9, a

manipulator 27 and storage devices 28 for wafers 29 are mounted.

INDUSTRIAL APPLICABILITY

The device operates as follows.

In the initial state, one of the storage devices 28 is provided with wafers 29, while the other is free from the wafers.

A manipulator 27 serves to grip a bottom wafer 29 in the storage device 28 and to transport it through a window 6 (with a shutter 7 opened by a drive 8) inwards a closed chamber 1.

At that moment, a first of the holders 14 is under loading. The manipulator 27 conveys the wafer 29 in a position below a horizontal platform 16 of the first holder 14.

By switching gas supplying means 4 in vortex chambers 25, 26 of the holder 14, gas vortex flows are generated to provide for the holding of the wafer 29 at a distance of about 0.5 - 1.0 mm from a level end surface of the platform 16 of the holder 14. At that moment, the manipulator 14 releases the wafer 29. The wafer has been loaded. Thereupon, the next wafer is loaded.

In an embodiment as illustrated here, a device for treating wafers with a plasma jet is provided with five wafer holders located at an angle of 72° to one another in the horizontal plane. Feeding the next holder in the loading zone is performed with an angular displacement drive 12 for the holder 14.

On loading of all the holders, the manipulator 27 is withdrawn from the closed chamber 1 while closing the shutter 7 with the drive 8. A required gas is supplied to the chamber.

By means of a support 15, a generator 10 of a plasma jet 11 is mounted, with respect to the surface of the wafer 29 to be treated, at a height suitable for a manufacturing process.

On switching the drive 18, the holders 14 start rotation, together with the wafers 29, about their axes. In so doing, a control system 5 is used to specify dynamics of the wafer movement. The generator 10 of the plasma jet 11 and the angular displacement drive 12 are switched and the treatment is carried out.

Following a prescribed number of contacts of the wafer 29 with the plasma jet 11 of the generator 10, the drive 12 is brought to a stop, under the predetermined program from the control system 5, such that none of the wafers 29 in the holders 14 falls within the zone of action of the generator plasma jet.

Then, the drive 18 and the generator 10 are turned off.

Hereinafter, the cycle is repeated using the next batch of wafers.

Various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims.